DOE/NV--951

U.S. DEPARTMENT OF ENERGY

Rio Blanco Site
ENVIRONMENTAL MANAGEMENT
END STATE VISION
Final

Executive Summary

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

Restoration activities have been conducted on the surface of the Rio Blanco Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Rio Blanco Site is located in the Piceance Creek Basin, in the southern region of Rio Blanco County, in northwest Colorado. The site is located approximately 36 miles northwest of Rifle and 52 miles northeast of Grand Junction. The Piceance Creek Basin is sparsely populated and the entire area is zoned by Rio Blanco County for agricultural use (DOE/NV, 2000b).

In May 1973, the U.S. Atomic Energy Commission (predecessor agency to the DOE) conducted a nuclear test at the Rio Blanco Site, as part of the Plowshare Program. This test was the third and final gas production experiment in the Plowshare Program. The test was designed to stimulate the flow of natural gas from low permeability sandstone formations which could not be economically produced through conventional methods (DOE/EM, 2001). Gas production testing and project evaluation activities were conducted at the Rio Blanco Site from 1973 until 1976, when the site was decommissioned and demobilized (DOE/NV, 2000b).

Site restoration activities were conducted at the Rio Blanco Site in 1976 and all affected areas were reshaped to as near the original contours as possible. During a corrective action investigation of the surface area in 2002, lead and diesel-range organics were detected above screening levels in several soil samples; however, a risk assessment for the site determined that these contaminants would not pose a risk to human health because they were present between 5 and 12 feet below ground surface. Groundwater samples taken in 2002 showed no contaminants of concern above screening levels (NNSA/NV, 2002).

Current land use for the Rio Blanco Site and surrounding areas consists primarily of livestock grazing, but also includes other agricultural and recreational uses (DOE/EM, 2001). The

Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division has concurred that no further action is required to "…assure that this property, when used for the purposes identified in the risk assessment, is protective of existing and proposed uses and does not pose an unacceptable risk to human health or the environment" (Stoner, 2003). Surface closure of the site was completed in fiscal year 2003. Therefore, the RBES has already been achieved for the surface of the Rio Blanco Site.

The subsurface contamination is being addressed by implementing an end state approach based on defining a contaminant boundary at the Rio Blanco Site and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the existing restriction boundary. Migration to the existing restriction boundary, both under non-stressed and stressed (production) conditions, is being evaluated. If migration is found to be significant (which may be determined by a risk assessment), then the restriction zone will be enlarged. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This approach will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the radionuclide transport model will be re-evaluated to determine if the drilling restriction area and associated institutional controls need to be changed.

According to the Life-Cycle Baseline Revision 5, the DOE Nevada Site Office (DOE/NSO) expects to complete closure of the Rio Blanco Site subsurface in fiscal year 2009. The DOE/NSO assumes that monitoring will be performed for 100 years (2009 to 2109), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Rio Blanco Site will be to continue monitoring and maintenance of institutional controls indefinitely.

The DOE/NSO has developed a public participation plan for the Rio Blanco Site End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

Table of Contents

List of Acronyms and Abbreviations

AEC	U.S. Atomic Energy Commission
bgs	Below ground surface
BLM	Bureau of Land Management
CDPHE	Colorado Department of Public Health and Environment
COC	Contaminant(s) of concern
^{137}Cs	Cesium-137
CSM	Conceptual site model
DOE	U.S. Department of Energy
DOE/NSO	U.S. Department of Energy, Nevada Site Office
DOI	U.S. Department of the Interior
EM	U.S. Department of Energy, Environmental Management Program
EPA	U.S. Environmental Protection Agency
F	Degrees Fahrenheit
FCG No.1	Fawn Creek Government Number 1 Well
ft	Foot (feet)
FY	Fiscal year
IDW	Investigation-derived waste
in.	Inch(es)
kt	Kiloton(s)
LTHMP	Long-Term Hydrologic Monitoring Program
MDC	Minimum detectable concentration
mg/kg	Milligrams per kilogram
mi	Mile(s)
mrem/yr	Millirem per year
pCi/g	Picocuries per gram
PLO	Public Land Order
SCF	Standard cubic feet
SGZ	Surface Ground Zero
TPH-DRO	Total petroleum hydrocarbons, diesel-range organics
TVD	Total vertical depth

1.0 Introduction

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

The Environmental Management End State Vision juxtaposes land use with remediation requirements, establishing a conceptual completion goal (or end state) that is both realistic and protective of human health and the environment. The purpose of the vision is to identify where and how potentially harmful exposures to hazardous or radioactive contaminants might occur under projected future conditions, and to determine what actions will be necessary to minimize the potential for harm under those conditions. Consistent with the objectives of cleanup, the vision conceptualizes specific end state conditions that will minimize the potential for harm in the future.

The July 2003 DOE Policy 455.1, "Use of Risk-Based End States," requires DOE Environmental Management Program (EM) sites to define and document a risk-based end state vision that is acceptable to regulators and stakeholders, and then to revise clean-up program plans as necessary to achieve that end state in the most efficient manner (DOE, 2003). The policy is a formal mandate for EM sites to implement risk-based corrective action programs as described in numerous DOE and U.S. Environmental Protection Agency (EPA) publications, American Society of Testing and Materials Standard Guides, and National Research Council recommendations.

Environmental corrective action is an application of standard scientific, engineering, and mathematical principles, enabling steady progress in solving even very complex clean-up problems. The complexities of cleanup at a typical EM site are generally similar: multiple contaminants distributed in multiple environmental media, released over long periods of time and over large areas of land. Uncertainties in source(s), nature, extent, transport, and fate of contaminants are very large and can never be absolutely eliminated. Corrective action provides an objective means of managing uncertainties to the degree necessary and sufficient to make defensible decisions about effective clean-up actions.

The end state vision describes clean-up goals that would be protective under planned future uses. Proposed corrective actions based on risk and other factors associated with land use are presented, negotiated, and agreed to by the State of Colorado and DOE.

The DOE's risk-based end state initiative is fully consistent with the EPA's recent endorsement of systematic planning, which uses risk-based decision methods to ensure objectivity, defensibility, and cost-effectiveness in corrective action programs (EPA, 2001). The DOE Nevada Site Office (DOE/NSO) will collaborate with its stakeholders to revise the proposed risk-based end state vision, as needed, to define clear goals for completion of its EM-sponsored clean-up work.

The DOE/NSO has developed a public participation plan for the Rio Blanco Site End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

Restoration activities have been conducted on the surface of the Rio Blanco Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Rio Blanco Site occupies approximately 25 acres in the Piceance Creek Basin in southern Rio Blanco County, Colorado. The site is located 36 miles (mi) northwest of Rifle and 52 mi northeast of Grand Junction. In 1973, the U.S. Atomic Energy Commission (AEC) (predecessor agency to the DOE) conducted a nuclear test at the Rio Blanco Site, under the Plowshare Program. The test consisted of the simultaneous detonation of three nuclear devices in one borehole. The test was designed to stimulate the flow of natural gas from low permeability sandstone formations that could not be economically produced through conventional methods (DOE/EM, 2001).

A corrective action investigation for the Rio Blanco Site was completed in 2002. This report characterized the nature of surface contamination at the site and provided a human health risk assessment. During the investigation, no gamma-emitting radionuclides were identified above background levels in the soil or groundwater at the site. Chemical contaminants of concern (COCs) above screening levels were detected in the soil and groundwater during the investigation; however, the risk assessment concluded that they do not pose a risk to human health under current and planned future land use. The report recommended that no corrective actions be required for the site (NNSA/NV, 2002). The Colorado Department of Public Health and Environment (CDPHE), Hazardous Materials and Waste Management Division has concurred that no further action is required to "…assure that this property, when used for the purposes identified in the risk assessment, is protective of existing and proposed uses and does not pose an unacceptable risk to human health or the environment" (Stoner, 2003). Surface closure of the Rio Blanco Site was completed in fiscal year (FY) 2003. Therefore, the RBES has already been achieved for the surface of the Rio Blanco Site.

The *Site Characterization Work Plan for the Rio Blanco Site* (DOE/NV, 2000b) describes the subsurface investigation of the Rio Blanco Site, with additional technical details available in *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs* (Cooper and Chapman, 2001). Upon construction of a dual-phase (liquid and gas) numerical flow and transport model, production stress will be applied to the modeled system to simulate gas development immediately beyond the current drilling restriction. The results will be analyzed, including a risk assessment if indicated, to determine if the current restrictions are sufficiently protective.

According to the Life-Cycle Baseline Revision 5, the DOE/NSO expects to complete closure of the Rio Blanco Site subsurface in FY 2009. The DOE/NSO assumes monitoring will be performed for 100 years (2009 to 2109), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Rio Blanco Site will be to continue monitoring and maintenance of institutional controls indefinitely.

The anticipated future use for the surface area (25 acres) is open space, primarily for livestock grazing (DOE/EM, 2001). Other agricultural and recreational uses may include farming, forestry, recreation, hunting, and accessory use (DOE/NV, 2000b). Deed restrictions are in place and are expected to prevent access to the test cavities, subsurface soil, natural gas, and groundwater in perpetuity (DOE/EM, 2001). A monument at surface ground zero (SGZ) lists the subsurface drilling restrictions (Johnston, 2003a). The DOE will retain long-term stewardship of the subsurface due to the presence of residual contamination and for national security concerns (DOE/EM, 2001).

1.1 Organization of the Report

The Rio Blanco Site End State Vision is organized into five sections. Since the current state and end state for the Rio Blanco Site are the same, only one map is presented for each subsection.

Section 1.0 introduces the site, including a brief discussion of past, present, and future site missions. This section also briefly discusses site hazards, the extent of environmental contamination, past remediation work, and any planned future clean-up work.

Section 2.0 describes the regional context end state. This section examines physical and surface interface and human and ecological land use in the regional context. A map showing the current state and the end state is also included for each subsection.

Section 3.0 describes the site-specific end state. This section examines physical and surface interface and human and ecological land use for the site and immediately adjacent lands. Legal ownership and demographics are also presented, and each subsection includes a map showing the current state and the end state.

Section 4.0 discusses specific site hazards including the nature of each hazard, potential impacts on human health and the environment, and any hazard mitigation identified. This section includes a current site-wide hazard map in addition to a current state/end state map for each specific hazard. A conceptual site model (CSM) is also included in this section. This model shows the current state/end state for each hazard. The CSM is used to show the known and potential contaminant pathways, potential receptors, and barriers that have been put in place to minimize exposure to contamination.

Section 5.0 provides references used to develop the Rio Blanco Site Environmental Management End State Vision.

Attachment A provides a report table detailing that there are no variances between the end state vision and current remediation plans for this site.

1.2 Site Mission

On May 17, 1973, the AEC conducted the Rio Blanco test under the Plowshare Program, which was a series of nuclear and conventional tests used to explore peaceful uses of nuclear detonations. The test consisted of the simultaneous detonation of three 33-kiloton (kt) nuclear devices at depths ranging from 5,838 to 6,689 feet (ft) below ground surface (bgs) in a single borehole. The test was designed to stimulate the flow of natural gas from low permeability sandstone formations that could not be economically produced through conventional methods. The Rio Blanco test was the third and final gas production experiment in the Plowshare Program (DOE/EM, 2001). Gas production testing and project evaluation activities were conducted at the Rio Blanco Site from 1973 until 1976, when the site was decommissioned and demobilized (DOE/NV, 2000b). Surface Rights at the Rio Blanco Site were withdrawn from the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM) in April of 1973 (DOE/NV, 2000b). The withdrawal was renewed for a period of 50 years in September of 2003. The Rio Blanco Site is currently managed by the DOI. The only ongoing DOE mission at the site is to continue long-term stewardship of residual subsurface contamination (DOE/EM, 2001; Stoner, 2003).

Based on the historic use of the Rio Blanco Site and characterization conducted at similar sites, COCs for the subsurface are expected to include radioactive fission products, plutonium, uranium, and tritium. Table 1.1 shows the representative source term for the Rio Blanco Site. At present, the hazard extent has not been defined for the subsurface; however, the DOE/NSO plans to complete the closure of the subsurface in FY 2009. The DOE/NSO assumes monitoring will be performed for 100 years (2009 to 2109), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Rio Blanco Site will be to continue monitoring and maintenance of institutional controls indefinitely.

The anticipated future use for the surface area (25 acres) is open space for grazing and recreational use; however, long-term stewardship activities have not been finalized with regulators. It is expected that deed restrictions will prevent access to the test cavities, subsurface soil, natural gas, and groundwater in perpetuity (DOE/EM, 2001).

Table 1.1 Representative Source Term for the Rio Blanco Site

Mean radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 at the Nevada Test Site. These data are decay corrected to January 1, 1994 (Smith, 2001). Site-specific unclassified mass estimates for the Rio Blanco test are substituted where available from Toman and Tewes (1972).

Radionuclide	Isotope Symbol	Half life ($t_{1/2}$; year)	Estimated Inventory (Ci) *
Tritium	H-3	1.23E+01	3.0E+03**
Carbon-14	C-14	5.73E+03	2.25E+01**
Aluminum-26	Al-26	7.30E+05	1.18E-04
Chlorine-36	Cl-36	3.01E+05	2.82E+00
Argon-39	Ar-39	2.69E+02	2.43E+01
Potassium-40	K-40	1.28E+09	6.17E+00
Calcium-41	Ca-41	1.03E+05	2.16E+01
Nickel-59	Ni-59	7.60E+04	5.25E-01
Nickel-63	Ni-63	1.00E+02	5.54E+01
Krypton-85	Kr-85	1.07E+01	2.0E+03**
Strontium-90	Sr-90	2.91E+01	1.57E+04
Zirconium-93	Zr-93	1.50E+06	5.49E-01
Niobium-93m	Nb-93m	1.61E+01	9.99E+01
Niobium-94	Nb-94	2.00E+04	2.28E+00
Technetium-99	Tc-99	2.13E+05	4.04E+00
Paladium-107	Pd-107	6.50E+06	2.07E-02
Cadmium-113m	Cd-113m	1.41E+01	1.53E+01
Tin-121m	Sn-121m	5.50E+01	5.67E+01
Tin-126	Sn-126	1.00E+05	6.47E-01
Iodine-129	I-129	1.57E+07	1.24E-02
Cesium-135	Cs-135	2.30E+06	4.17E-01
Cesium-137	Cs-137	3.02E+01	1.99E+04
Samarium-151	Sm-151	9.00E+01	7.51E+02
Europium-150	Eu-150	3.60E+01	1.46E+01
Europium-152	Eu-152	1.35E+01	4.33E+02
Europium-154	Eu-154	8.59E+00	2.04E+02
Holmium-166m	Hm-166m	1.20E+03	5.89E-01
Thorium-232	Th-232	1.40E+10	7.68E-04
Uranium-232	U-232	7.00E+01	3.36E+00
Uranium-233	U-233	1.59E+05	2.25E+00
Uranium-234	U-234	2.46E+05	1.62E+00
Uranium-235	U-235	7.04E+08	2.18E-02
Uranium-236	U-236	2.34E+07	6.22E-02
Uranium-238	U-238	4.47E+09	2.88E-02
Neptunium-237	Np-237	2.14E+06	4.80E-01
Plutonium-238	Pu-238	8.77E+01	9.42E+01
Plutonium-239	Pu-239	2.41E+04	2.54E+02
Plutonium-240	Pu-240	6.56E+03	8.16E+01
Plutonium-241	Pu-241	1.44E+01	1.18E+03
Plutonium-242	Pu-242	3.75E+05	4.42E-02
Americium-241	Am-241	4.33E+02	6.14E+01
Americium-243	Am-243	7.37E+03	2.36E-03
Curium-244	Cm-244	1.81E+01	3.91E+01

*Except where noted, value is from the mean unclassified radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 of the Nevada Test Site.
**Value is an unclassified estimate for the Rio Blanco test specifically, from Toman and Tewes (1972).

1.3 Status of Clean-up Program

The Rio Blanco Site demobilization and restoration activities were conducted from July to November 1976, and included plugging and abandonment of Wells RB-E-01, RB-AR-2, and RB-U-4 and recompletion of the Fawn Creek Government Number 1 (FCG No.1) Well. No subsurface restoration work was undertaken for the RB-D-01, RB-W-1, and RB-S-3 Wells at the RB-E-01 Drill Pad. The three wells were considered radiologically clean but were left in place for hydrologic monitoring (DOE/NV, 2000b).

Prior to final site grading, a radiological soil sampling program was conducted. During this investigation, it was determined that concentrations of radionuclides measured in soil samples were not distinguishable from natural background levels, with the exception of tritium, which exceeded the federal criterion of 110 picocuries per gram (pCi/g) in several samples (DOE/NV, 2000b).

All affected areas at the Rio Blanco Site were reshaped to as near the original contours as was practical. Stockpiled topsoil was redistributed over the graded area at the RB-U-4 Drill Pad, and the Fawn Creek dirt road was realigned to approximate its original course in the vicinity of the RB-E-01 Drill Pad. The mud pits were backfilled with clean native soil (DOE/NV, 2000b).

A corrective action investigation and risk assessment for the Rio Blanco Site surface were completed in 2002. The investigation determined that no gamma-emitting radionuclides above background levels were present in the soil or groundwater at the site. Chemical COCs above screening levels were detected in the soil and groundwater during the investigation; however, the risk assessment concluded that they were not present in sufficient quantities to pose a risk to human health. The report recommended that no corrective actions be required and that no surface use restrictions be placed on the site (NNSA/NV, 2002). The CDPHE has concurred that no further action is required to "…assure that this property, when used for the purposes identified in the risk assessment, is protective of existing and proposed uses and does not pose an unacceptable risk to human health or the environment" (Stoner, 2003). Surface closure of the Rio Blanco Site was completed in FY 2003. Therefore, the end state has already been achieved for the surface of the Rio Blanco Site.

A monument has been placed at the Rio Blanco Site SGZ in order to mark the location of the test cavities (Johnston, 2003a). An assessment of the potential to contaminate area aquifers was conducted in 1996. The results of the assessment showed that radionuclides posed little threat to area aquifers (Chapman et al., 1996). The DOE/NSO has not completed characterization of the subsurface at the site, but does not plan to remove subsurface contamination in or around the test cavities due to the lack of feasible remediation technology. According to the Life-Cycle Baseline Revision 5, the DOE/NSO expects to complete closure of the subsurface in FY 2009. The DOE/NSO assumes monitoring will be performed for 100 years (2009 to 2109), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Rio Blanco Site will be to continue monitoring and maintenance of institutional controls indefinitely.

2.0 Regional Context End State Description

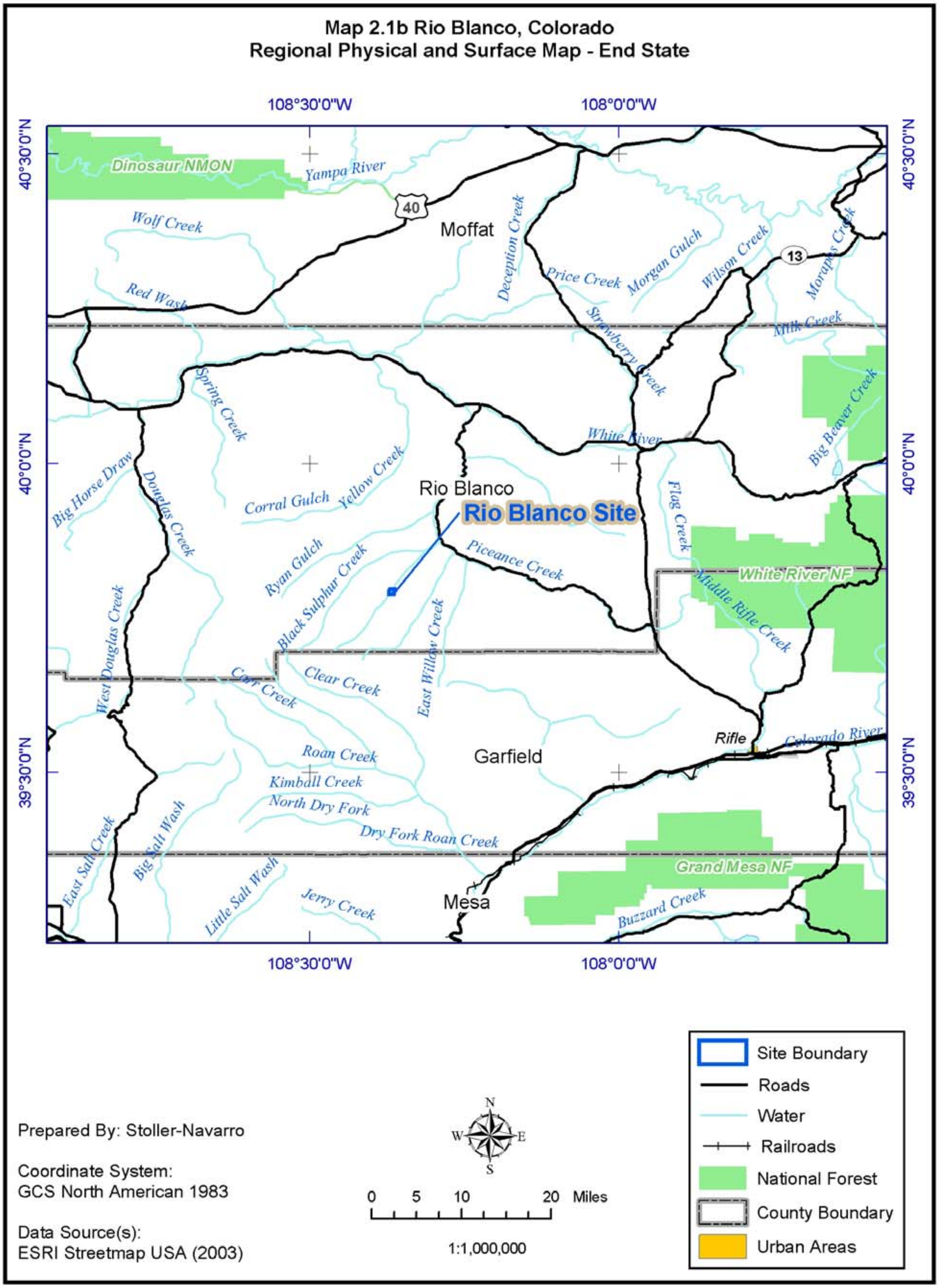
This section examines physical and surface interface and human and ecological land use in the regional context. This section also provides a discussion of current and planned future land use for the region surrounding the Rio Blanco Site.

2.1 Regional Physical and Surface Interface

The Piceance Creek Basin is located in the center of Colorado's oil shale deposits and covers approximately 2,185 square miles (Map 2.1b). This basin is underlain with relatively erodible rocks of the Wasatch Formation and more resistant layers of the Green River Formation, the latter of which contains oil shale beds up to 3,500 ft thick at variable depths. Variation in the terrain includes rugged badlands, abrupt cliffs, sharp ridges, broad open valleys, upland parks, smaller basins, and low to moderately high rounded hills. Elevations on the basin range from 5,400 to over 8,700 ft (CER Geonuclear Corp., 1971).

Westward-flowing White River at the basin's north boundary and northward-flowing Yellow and Piceance Creek tributaries are the principal drainageways. Many other smaller tributaries finely dissect the landscape (CER Geonuclear Corp., 1971).

The climate of Piceance Creek Basin can generally be described as semi-arid, with comparatively warm summers and cold winters. Mean annual temperatures range from 47 degrees Fahrenheit (°F) at the lowest elevations to less than 40°F at the higher elevations. Mean annual precipitation varies from 12 to 25 inches (in.) and is distributed somewhat uniformly throughout the year. Cloudbursts are common summer occurrences at lower elevations and can produce high-peak-flow floods of short duration, resulting in channel cutting and bottomland flood deposits (CER Geonuclear Corp., 1971).


Map 2.1b Rio Blanco, Colorado
Regional Physical and Surface Map - End State
108°30'0"W
108°0'0"W
40°30'0"N
40°0'0"N
39°30'0"N
Dinosaur NMON
Yampa River
40
Wolf Creek
Moffat
Deception Creek
Red Wash
Price Creek
Morgan Gulch
Wilson Creek
13
Morapos Creek
Milk Creek
Strawberry Creek
Spring Creek
White River
Big Beaver Creek
Big Horse Draw
Douglas Creek
Corral Gulch
Yellow Creek
Rio Blanco
Rio Blanco Site
Flag Creek
Piceance Creek
Ryan Gulch
Black Sulphur Creek
White River NF
Middle Rifle Creek
West Douglas Creek
East Willow Creek
Clear Creek
Carr Creek
Rifle
Colorado River
Roan Creek
Garfield
Kimball Creek
North Dry Fork
Dry Fork Roan Creek
East Salt Creek
Big Salt Wash
Grand Mesa NF
Little Salt Wash
Jerry Creek
Mesa
Buzzard Creek
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
ESRI Streetmap USA (2003)
N
W
E
S
0 5 10 20 Miles
1:1,000,000
Site Boundary
Roads
Water
Railroads
National Forest
County Boundary
Urban Areas

2.2 Human and Ecological Land Use

Human Land Use

Rio Blanco County is a sparsely populated area. The entire Piceance Creek Basin is zoned by Rio Blanco County for agricultural use, which permits agricultural farming, ranching, forestry, recreation, hunting, and accessory use (Map 2.2b). The principal land use in the area is livestock grazing (DOE/NV, 2000b); however, the area surrounding the Rio Blanco Site is covered by oil and gas leases.

Future land use for the region surrounding the Rio Blanco Site is expected to be similar to present activities in the area (ranching, oil and gas development, and public recreation). According to the *White River Resource Area Proposed Resource Management Plan and Final Environmental Impact Statement*, future development of oil and gas wells will likely be concentrated around existing known large reserves (BLM, 1996).

The anticipated future use for the surface of the Rio Blanco Site is open space for grazing and recreation; however, access to the subsurface will continue to be restricted (Johnston, 2003b). The DOE will continue long-term stewardship activities for residual subsurface contamination. This stewardship will entail continued monitoring of groundwater quality in and near the Rio Blanco Site, as well as maintaining subsurface drilling restrictions and institutional controls sufficient to isolate subsurface contamination from potential land users. As part of the Long-Term Hydrologic Monitoring Program (LTHMP), the EPA annually samples 15 locations on and around the Rio Blanco Site, including four springs, four surface sites, and five wells, three of which are located near the cavities (EPA, 2002). No radioactive materials attributable to the Rio Blanco test were detected off site in the samples taken between 2000 and 2002 (NNSA/NV, 2002).

Public Land Order (PLO) 7582 was issued in September of 2003 to renew the withdrawal of the entire original 360-acre Rio Blanco Site for 50 years (*Federal Register*, 2003). According to the BLM, no public comments have been received regarding the notice in the *Federal Register* and no adverse environmental impacts were noted in regard to the new withdrawal (Johnston, 2003a). The future roles and responsibilities of the DOE, landowners, and other federal and state agencies are documented in Table 2.1.

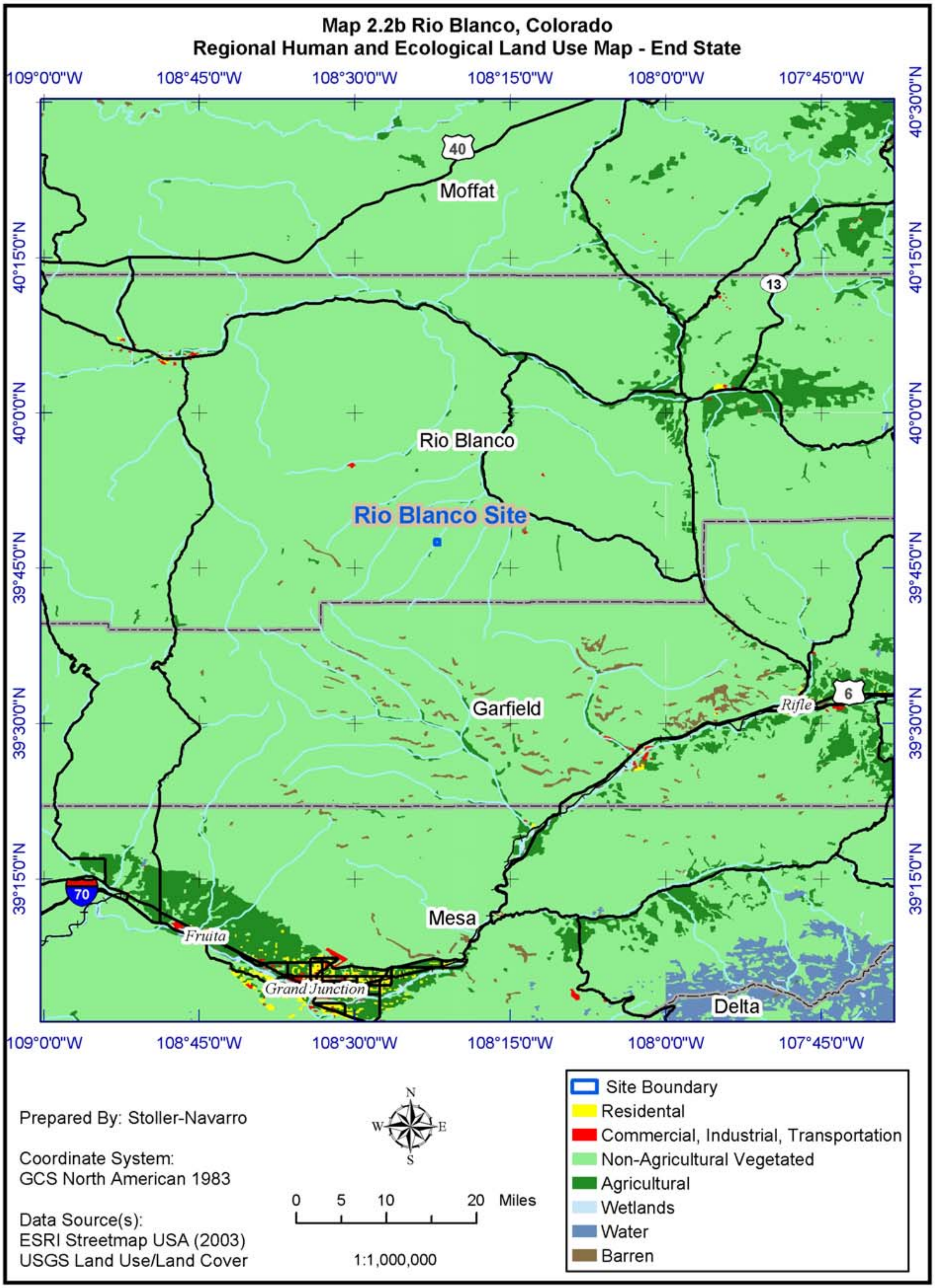

Map 2.2b Rio Blanco, Colorado
Regional Human and Ecological Land Use Map - End State
109°0'0"W
108°45'0"W
108°30'0"W
108°15'0"W
108°0'0"W
107°45'0"W
40°30'0"N
40°15'0"N
40°0'0"N
39°45'0"N
39°30'0"N
39°15'0"N
40
Moffat
13
Rio Blanco
Rio Blanco Site
Garfield
Rifle
6
70
Fruita
Mesa
Grand Junction
Delta
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
ESRI Streetmap USA (2003)
USGS Land Use/Land Cover
N
W
E
S
0 5 10 20 Miles
1:1,000,000
Site Boundary
Residental
Commercial, Industrial, Transportation
Non-Agricultural Vegetated
Agricultural
Wetlands
Water
Barren

Table 2.1
DOE/NSO Land Status

Landlord	Surface Steward	Subsurface Steward	Withdrawal Order/Law	Specific Restriction Record	Oil/Gas Owner and Leases	Water Well Permits	Mineral Rights	Grazing Rights
DOI (BLM) and Private Land Owner	BLM and Private Owner	**Current:** DOE/NSO and BLM **Future:** DOE/Office of Legacy Management	**Surface:** PLO 7582 **Subsurface:** PLO 7582	Recorded in PLO and on-site plaque	BLM and Private Owner Known Leases	None Listed – DOE Wells Exist	U.S. Government	Private and BLM issued

Ecological Land Use

The Rio Blanco area is dominated by arid piñon-juniper woodland on the rocky slopes, and woodlands with dense stands of large sagebrush in the finer alluvial soils between the ridges. A total of 1 reptile, 36 bird, and 11 mammal species are native to the area. No threatened or endangered species have been identified in the region (DOE/NV, 1993c). Large animals including black bears, buffalo, elk, mountain lions, and mule deer have been known to frequent the Piceance Creek Basin, and wild horses may reside in the area, as well (CER Geonuclear Corp., 1971).

3.0 Site-Specific End State Description

This section examines physical and surface interface and human and ecological land use in the site-specific context. This section also provides a discussion of current and planned future land use for the site, legal ownership of the site and immediately adjacent lands, and demographics for the area.

3.1 Physical and Surface Interface

The Rio Blanco Site is located in the Piceance Creek Basin, a large structural and sedimentary basin over 27,880 ft thick, containing sedimentary rocks from Cambrian to recent age. Mineral resources in the Piceance Creek Basin include coal, oil, gas, and oil shale. Groundwater occurs in surficial alluvium found along major drainages, and in the Green River Formation. Below the Green River Formation (Wasatch, Fort Union, and Mesaverde Formations), rocks are frequently gas-bearing, have low permeability, and consist of discontinuous sandstone lenses within clay and shale. The units below the Green River Formation are not known to yield water to wells. A three-dimensional cross section of the Rio Blanco Site is provided in Figure 3.1.

All three nuclear devices were detonated in the Mesaverde Formation. The dip of the Mesaverde is not strictly known in the vicinity of the emplacement well. However, the structure of the underlying Jurassic Dakota sandstone is known, and the dip of it is to the northeast at 0.19 meter per meter. Because the Mesaverde and Dakota sandstones underwent the same orogeny, and therefore, have similar tectonic history and deformation, it is assumed that both formations have the same strike and dip. The gas reservoirs at the Rio Blanco Site are unconventional, as they cut across stratigraphic units, are commonly structurally downdip from water-saturated formations, and have no obvious trapping mechanism (Johnson, 1989). In general, the low-permeability gas reservoirs do not have discrete gas/water contacts in any of the fields within the Piceance Basin. Accurate measurements of pressure are largely absent, as most drill-stem tests were not run to completion because the pressure buildup time was very slow due to the extremely low permeability.

The surface of the Rio Blanco Site is characterized by a trellis-like network of southwest-northeast flowing drainages. This drainage pattern produces a series of nearly parallel, relatively wide ridges that are oriented to the northeast. The approximate elevation of the Rio Blanco Site is 6,630 ft. Elevations range from 6,560 ft along the drainage to 7,000 ft on the wide ridges bordering the valley drainage on the east and west (DOE/NV, 2000b).

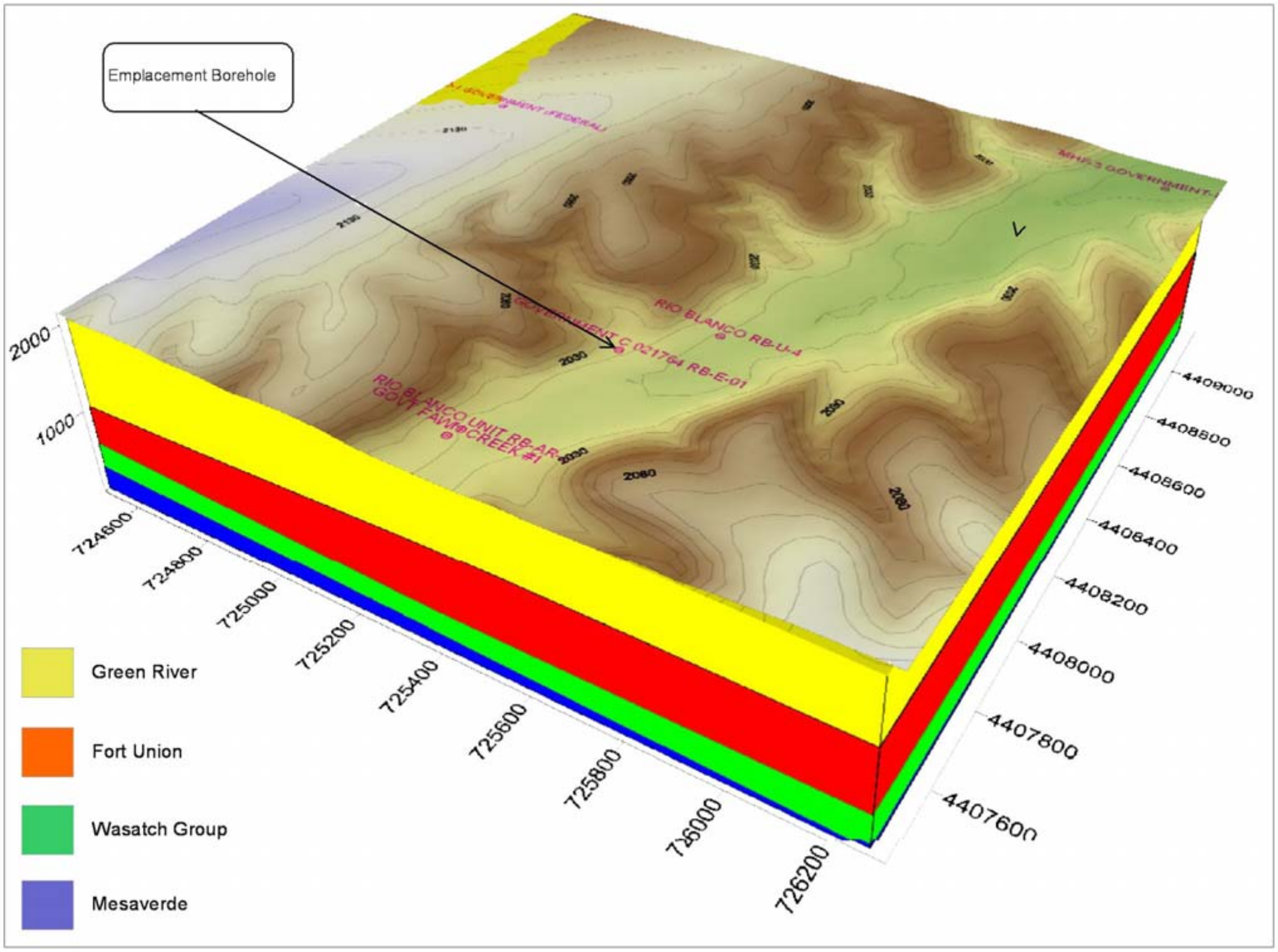
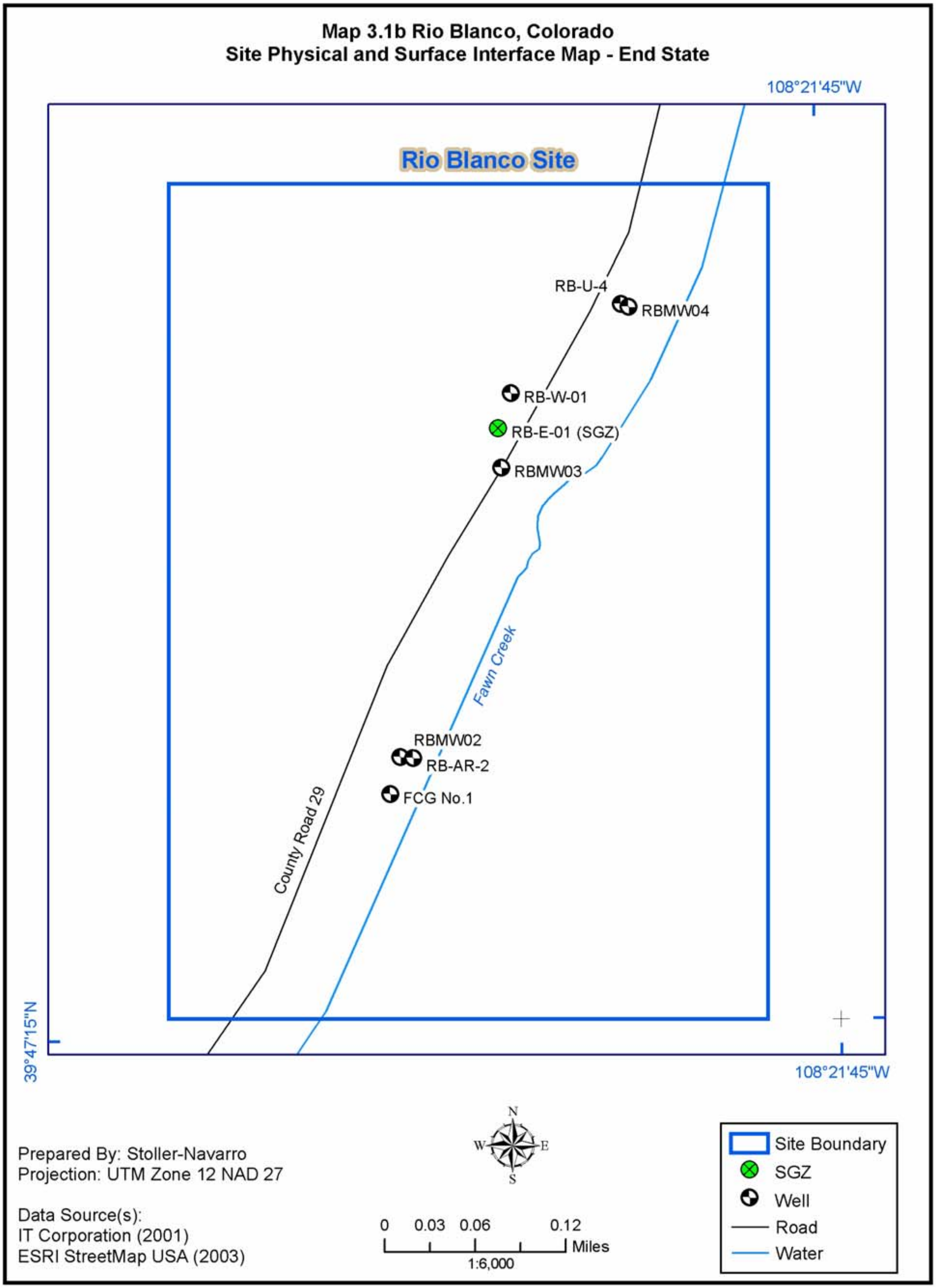


Figure 3.1

Three-Dimensional Cross Section View Looking Northward Across the Rio Blanco Site (Cooper and Shirley, 2004)

Surface water is confined to the steeply walled Fawn Creek located on the eastern half of the Rio Blanco Site (Map 3.1b). Fawn Creek flows past the site from south to north in a well-carved, relatively narrow channel, with banks that exceed 20 ft in height at some locations. Fawn Creek is ephemeral and experiences high spring and low summer flows. Fawn Creek is a tributary to Black Sulfur Creek, which drains into Piceance Creek (DOE/NV, 2000b). According to a Floodplains and Wetlands Survey conducted in the area, Fawn Creek is the only environmentally sensitive wetland area at the site (DOE/NV, 1993b).


Map 3.1b Rio Blanco, Colorado
Site Physical and Surface Interface Map - End State
108°21'45"W
Rio Blanco Site
RB-U-4
RBMW04
RB-W-01
RB-E-01 (SGZ)
RBMW03
Fawn Creek
RBMW02
RB-AR-2
FCG No.1
County Road 29
39°47'15"N
108°21'45"W
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
IT Corporation (2001)
ESRI StreetMap USA (2003)
0 0.03 0.06 0.12
Miles
1:6,000
Site Boundary
SGZ
Well
Road
Water

3.2 Human and Ecological Land Use

Human Land Use

The entire Piceance Creek Basin is zoned by Rio Blanco County for agricultural use, which permits agricultural farming, ranching, forestry, recreation, hunting, and accessory use (Map 3.2b). The principal land use in the area of the Rio Blanco Site is livestock grazing (DOE/NV, 2000b). A Class III Cultural Resources Survey indicated that there is a low density of prehistoric cultural resources in the area and the potential for significant undetected cultural material appears to be low (DOE/NV, 1993a).

Current restrictions on subsurface intrusion (drilling) around the Rio Blanco Site SGZ, shown in Map 3.2b, are as follows:

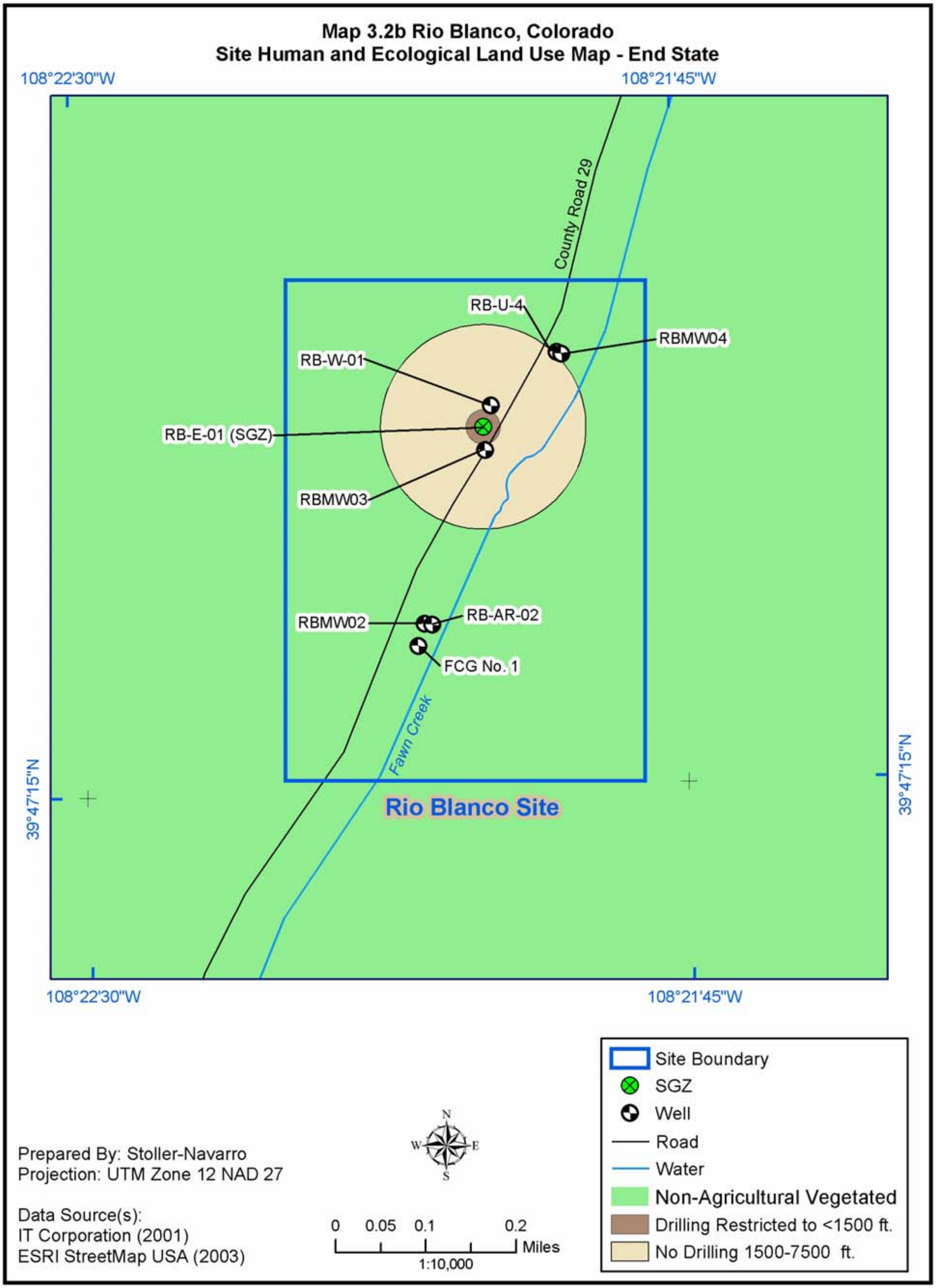
- Within a 100-ft radius, no intrusion is allowed from the surface to 1,500 ft total vertical depth (TVD).
- Within a 600-ft radius, no intrusion is allowed from between 1,500 and 7,500 ft TVD (DOE/NV, 2000b).

These restrictions are listed on the plaque attached to the SGZ monument at the Rio Blanco Site (Johnston, 2003a).

The Rio Blanco Site wells are located in the flat terraced area of the sagebrush shrub community, and the former Flare Stack area is located in the higher elevation piñon-juniper woodlands area. No drilling activities occurred within the eroded channel of Fawn Creek (DOE/NV, 2000b).

There are currently no permanent residences on the Rio Blanco Site. A trailer near the RB-U-4 site serves as a temporary residence during cattle round-ups and is occupied several weeks a year. The trailer has access to the RB-D-03 Well; however, based on the most recent groundwater sampling in 2002, there are no human health risks from site constituents (NNSA/NV, 2002).

The DOE/NSO developed a public participation plan for the Rio Blanco Site RBES Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.



Map 3.2b Rio Blanco, Colorado
Site Human and Ecological Land Use Map - End State
108°22'30"W
108°21'45"W
39°47'15"N
County Road 29
RB-U-4
RBMW04
RB-W-01
RB-E-01 (SGZ)
RBMW03
RBMW02
RB-AR-02
FCG No. 1
Fawn Creek
Rio Blanco Site
Site Boundary
SGZ
Well
Road
Water
Non-Agricultural Vegetated
Drilling Restricted to <1500 ft.
No Drilling 1500-7500 ft.
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
IT Corporation (2001)
ESRI StreetMap USA (2003)
0 0.05 0.1 0.2 Miles
1:10,000
N
W
E
S

Ecological Land Use

The Rio Blanco Site is characterized by three distinct ecologic communities. The first is the piñon-juniper woodlands associated with the steep slopes and higher elevated plateaus. The second is the sagebrush shrub community in the flat terrace between the higher elevations and Fawn Creek. The third community is within the eroded channel of Fawn Creek (DOE/NV, 2000b). The creek is ephemeral and is often dry by mid-July. Heavy cattle grazing in the sagebrush and along Fawn Creek has created access to the creek from above the creek bed, but has limited the diversity. Use of the site by resident and migrant wildlife is limited to travel from the ridges to the creek and back. The dense sagebrush provides poor forage for deer and elk, but does offer a nesting habitat for small birds. Migratory elk and mule deer occupy the ridges, where piñon nuts, juniper berries, and grasses provide sustenance. Willow and other wetland shrubs provide food for ducks and beavers along the banks of the creek. According to a sensitive species survey conducted in the area, no threatened or endangered species have been observed at the site (DOE/NV, 1993c).

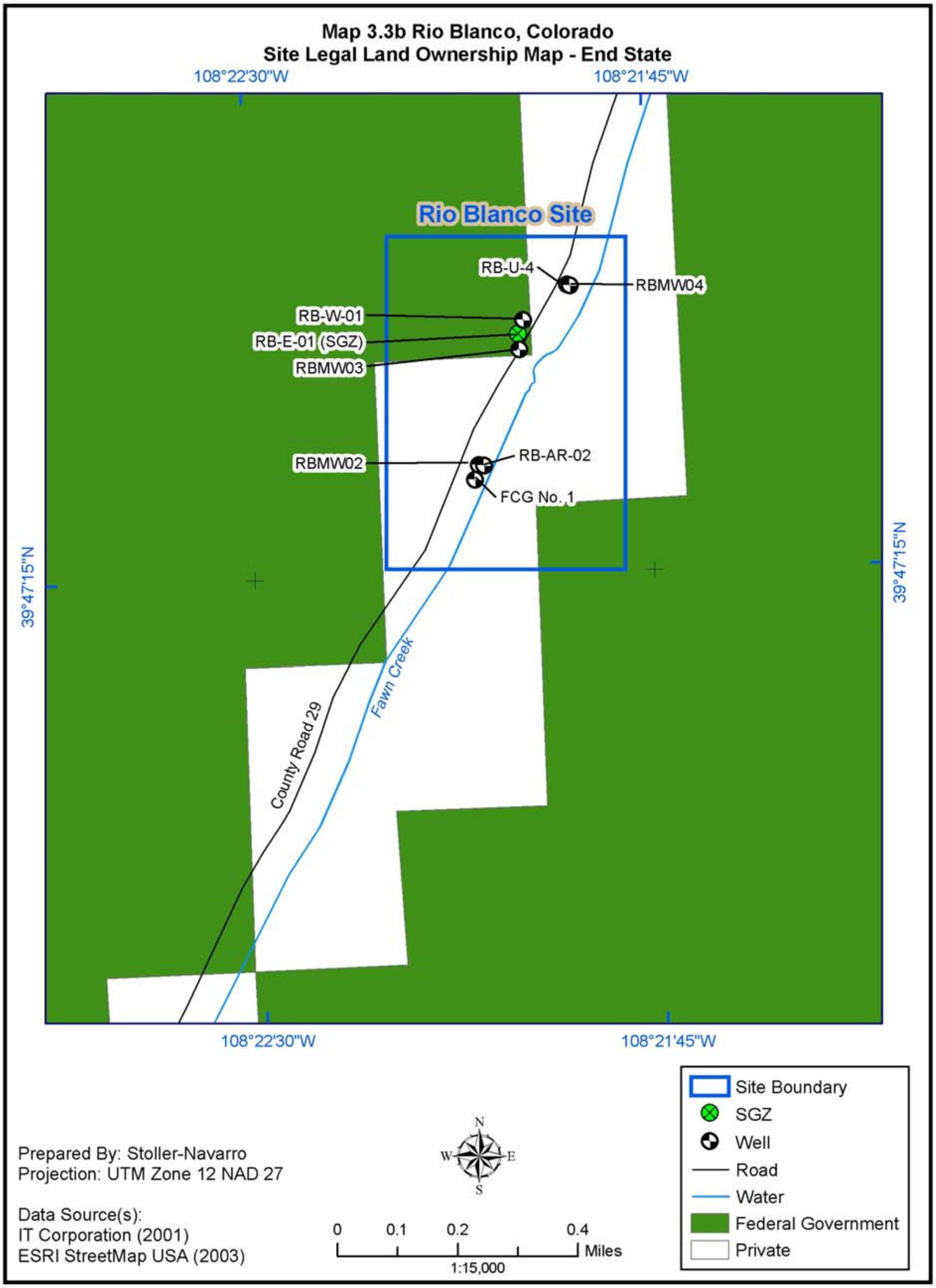
The terrain affected by operations was reshaped to approximate its original undisturbed form; however, operational areas were revegetated with a wheat-type grass instead of the thick sage growth covering the surrounding areas (DOE/NV, 2000b).

3.3 Site Context Legal Ownership

The Rio Blanco Site was originally withdrawn under PLO 5344 (Map 3.3b), as noted in the *Federal Register*, Vol. 38, No. 81, dated April 27, 1973 (*Federal Register*, 1973). The withdrawal specified two separate parcels as follows: 1) southeast ¼ of the southeast ¼ of Section 10, southwest ¼ of the southwest ¼ of Section 11, northwest ¼ of the northwest ¼ of Section 14, and east of the northeast ¼; and 2) southeast ¼ of the southwest ¼ of Section 11, east ½ of the northwest ¼ and southwest ¼ of the northwest ¼ of Section 14. The first parcel was withdrawn from all forms of disposition under the public land laws, including the U.S. mining laws, and from leasing under the mineral leasing laws. On the second parcel, the minerals were reserved to the United States from this patented land (currently privately owned by Fawn Creek, Inc.) and were withdrawn from disposition under the U.S. mining laws and from leasing under the mineral leasing laws. PLO 5344 (*Federal Register*, 1973) supplemented a withdrawal of lands for oil shale made under Executive Order No. 5327 and PLO 4522 (*Federal Register*, 1968). Included in PLO 5344, as published in the Federal Register, is a figure of Section 14 specifying strict limitations on drilling in the immediate vicinity of the SGZ (*Federal Register*, 1973). In the *Federal Register*, Vol. 67, No. 51, dated March 15, 2002, it was noted that PLO

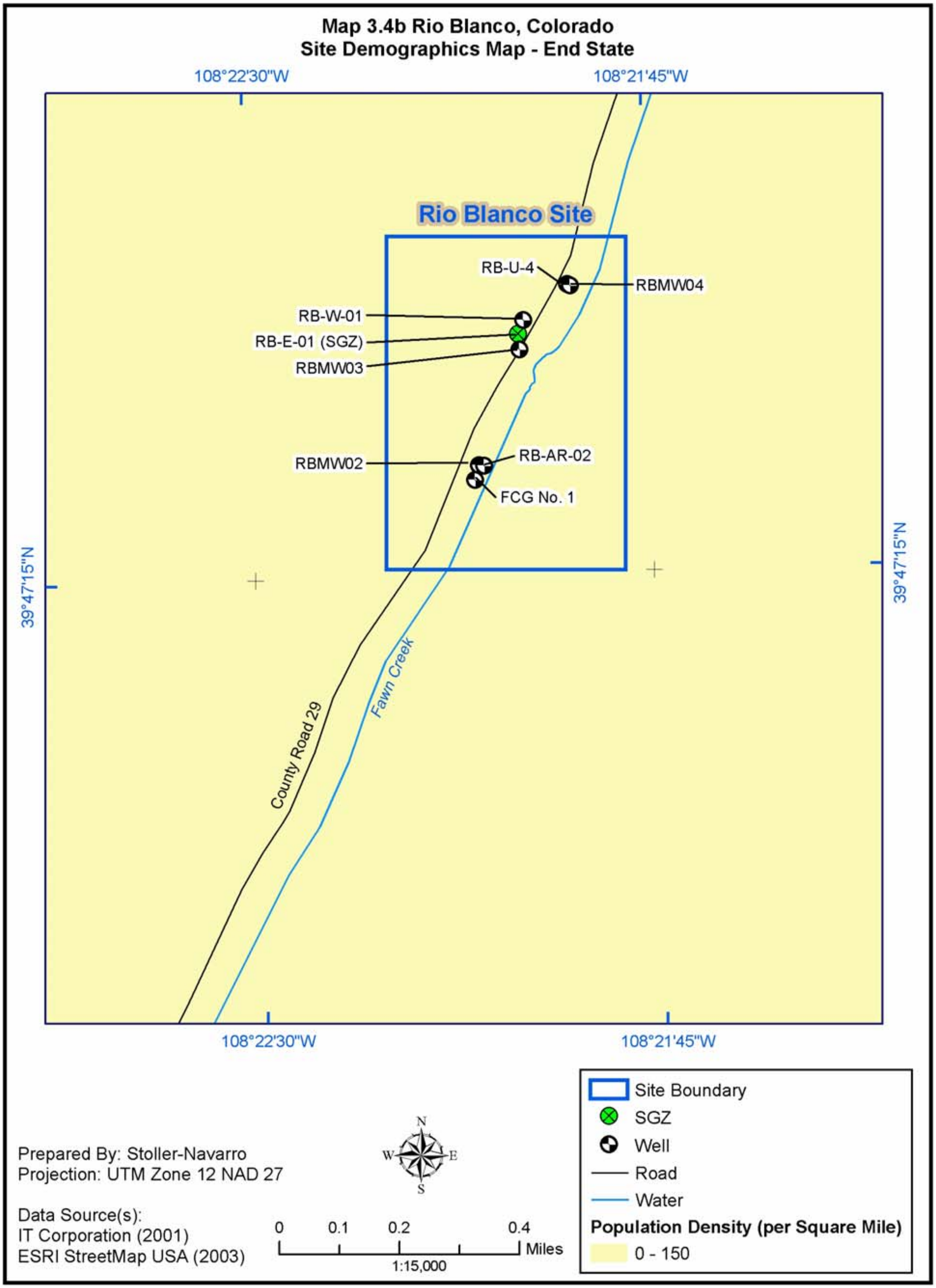
7516 was issued to revoke oil shale withdrawals in the State of Colorado and open approximately 900,000 acres of public lands to surface entry and mining, including mineral leasing (*Federal Register*, 2002). However, as noted in the *Federal Register*, Vol. 68, No. 181, dated September 18, 2003, PLO 7582 was issued to renew the withdrawal of the entire original 360-acre Rio Blanco Site from mining, in order to protect the public from subsurface contamination. This withdrawal will continue for a period of 50 years (*Federal Register*, 2003).

According to the Master Title Plat for Township 3 South, Range 98 West, there are no oil or gas wells on the Rio Blanco Site, but there are two oil and gas leases. The private land parcel of the site includes an oil and gas lease, but it is located within the 600-ft radius around the SGZ in which drilling is restricted between 1,500 and 7,500 ft TVD. Fawn Creek, Inc. owns all water rights to the land (Johnston, 2003a); however, well permits are required for all water, oil, and gas wells, and the Master Title Plat will be consulted before any well permits are issued.


Map 3.3b Rio Blanco, Colorado
Site Legal Land Ownership Map - End State
108°22'30"W
108°21'45"W
39°47'15"N
Rio Blanco Site
RB-U-4
RBMW04
RB-W-01
RB-E-01 (SGZ)
RBMW03
RBMW02
RB-AR-02
FCG No. 1
County Road 29
Fawn Creek
Site Boundary
SGZ
Well
Road
Water
Federal Government
Private
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
IT Corporation (2001)
ESRI StreetMap USA (2003)
0
0.1
0.2
0.4
Miles
1:15,000
N
S
E
W

3.4 Site Context Demographics

According to the U.S. Census Bureau, the entire population of Rio Blanco County is less than 6,000 (Map 3.4b). Grand Junction is the largest community in the vicinity of the site. It is located in Mesa County, 52 mi southwest of the site, and has a population of approximately 42,000. Rifle, the closest community to the Rio Blanco Site, is located in Garfield County, 36 mi southeast of the site, and has a population of approximately 7,000. The economy of the region is supported mainly by agriculture, and the entire area surrounding the site is zoned for grazing (U.S. Census Bureau, 2000). It is not anticipated that the human population near the Rio Blanco Site will increase significantly in the foreseeable future.


Map 3.4b Rio Blanco, Colorado
Site Demographics Map - End State
108°22'30"W
108°21'45"W
39°47'15"N
Rio Blanco Site
RB-U-4
RBMW04
RB-W-01
RB-E-01 (SGZ)
RBMW03
RBMW02
RB-AR-02
FCG No. 1
Fawn Creek
County Road 29
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
IT Corporation (2001)
ESRI StreetMap USA (2003)
N
W
E
S
0
0.1
0.2
0.4
Miles
1:15,000
Site Boundary
SGZ
Well
Road
Water
Population Density (per Square Mile)
0 - 150

4.0 Hazard Specific Discussion

The Rio Blanco Site consisted of four distinct but similar operational areas:

- RB-E-01 Drill Pad
- Flare Stack location
- RB-AR-2/FCG No. 1 Drill Pad
- RB-U-4 Drill Pad

Since all of the surface hazards at these sites have been removed, they do not appear on Map 4.0b.

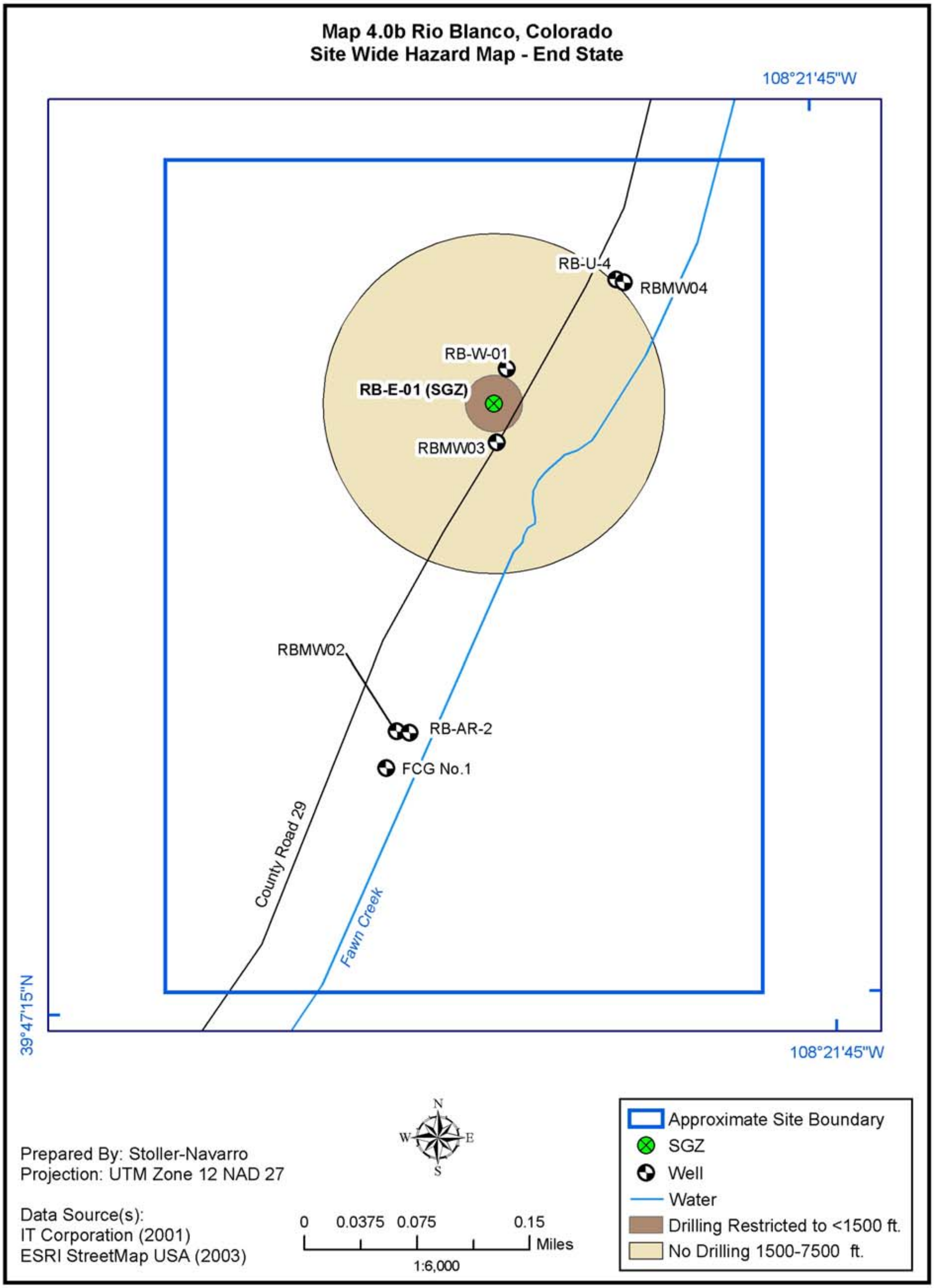
Each of the above listed drill pads were believed to include the following potential sources of contamination (DOE/NV, 2000b):

- Closed drilling mud pits
- Septic tanks
- Storage areas
- Spills
- Trash pits

COCs for each of the sites included the following (NNSA/NV, 2002):

- Total petroleum hydrocarbons (TPH) diesel-range organics (DRO)
- Tritium
- Cesium-137 (^{137}Cs)
- Lead

According to available historical documentation, no chemical release sites were identified and no radioactive or chemical material was buried at the Rio Blanco Site. Contaminated soil, solid waste, and solidified liquids that resulted from decontamination and site cleanup were removed and shipped to the Nevada Test Site for disposal. All operational support equipment and infrastructure were removed from the site as part of the final site demobilization and restoration. Radioactively contaminated liquid waste (tritium) was injected into FCG No. 1 (DOE/NV, 2000b).


Map 4.0b Rio Blanco, Colorado
Site Wide Hazard Map - End State
108°21'45"W
RB-U-4
RBMW04
RB-W-01
RB-E-01 (SGZ)
RBMW03
RBMW02
RB-AR-2
FCG No.1
County Road 29
Fawn Creek
39°47'15"N
108°21'45"W
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
IT Corporation (2001)
ESRI StreetMap USA (2003)
0 0.0375 0.075 0.15 Miles
1:6,000
Approximate Site Boundary
SGZ
Well
Water
Drilling Restricted to <1500 ft.
No Drilling 1500-7500 ft.

Upon completion of the Surface Corrective Action Investigation Report for the Rio Blanco Site, it was determined that no corrective actions would be required at any of the operational areas (NNSA/NV, 2002). The CDPHE has concurred that no further action is required to "…assure that this property, when used for the purposes identified in the risk assessment, is protective of existing and proposed uses and does not pose an unacceptable risk to human health or the environment" (Stoner, 2003). Surface closure of the Rio Blanco Site was completed in FY 2003. Therefore, the end state has already been achieved for the surface of the Rio Blanco Site.

The objectives of future monitoring for the Rio Blanco Site subsurface will be risk-based. A significant radionuclide source will be left in place; therefore, the area restricted to resource extraction will be based on numerical models that entail significant, irreducible uncertainties. The possibility of error and accompanying risk to the public dictate the need for monitoring. The details of post-closure monitoring will need to be agreed to not only by the DOE, but also by the State of Colorado. To date, the State has been forming decisions consistent with risk as the driver. Table 4.1 summarizes the hazards and risks associated with the site (DOE/NV, 2000a).

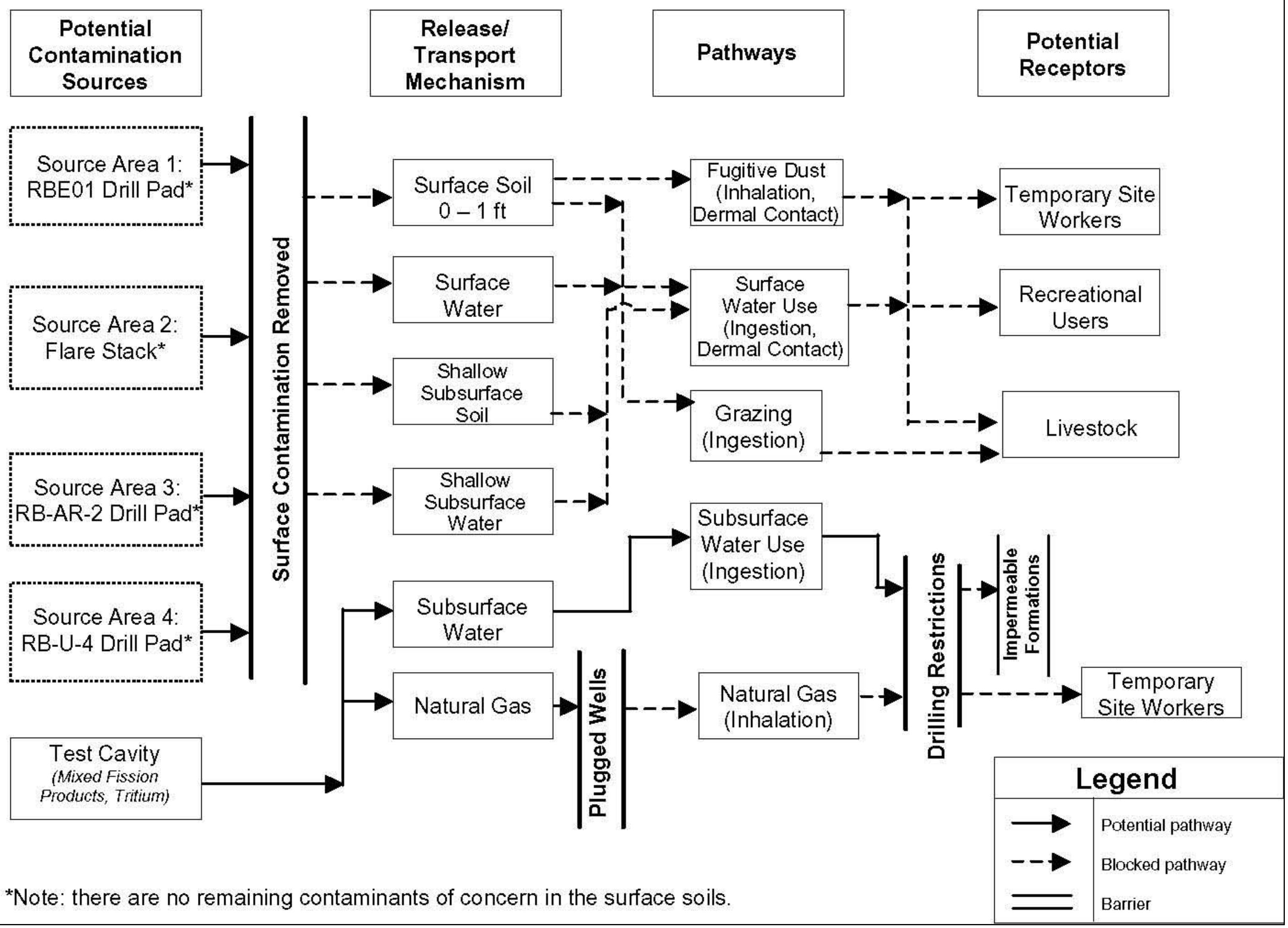
A CSM for the site is provided in Figure 4.0. The CSM illustrates the relationship between the identified potential sources of contamination, the mechanisms for release and migration away from the potential source, the pathways the contamination would follow once released, the exposure routes by which potential contamination would affect receptors, and the receptors that would be impacted by potential contamination (DOE/NV, 2000b).

A description of the subsurface hazard area is provided below. No surface hazards remain at the Rio Blanco Site; however, a description of the surface operational areas that received clean closure is also provided in the following sections.

Table 4.1
Rio Blanco Site Hazards and Risks

Material Category	Nature of Hazard	Nature of Potential Risk	Status of Current Management	Planned Risk-Reduction Control	Anticipated Risk-Reduction Progress	End-State Disposition and Risk
Deep (>5,000 ft bgs) natural gas, groundwater and test cavities	Natural gas and groundwater in the immediate vicinity of the test cavities is contaminated with radionuclides (tritium and mixed fission products). Migratory potential of the contaminants via natural gas from the test cavities is being modeled.	Migration potential of radionuclides in natural gas and groundwater is minimal. Existing monitoring data from surrounding wells have not indicated radionuclide contamination. If contaminant migration is verified, the most probable exposure scenarios would be via inhalation of, ingestion of, and dermal contact with natural gas.	Site subsurface characterization, risk analysis, and natural gas modeling activities are ongoing. Site subsurface access is restricted.	Subsurface restrictions and institutional controls are in place and maintained. The subsurface risk-based compliance boundary will be refined based on subsurface modeling results. A refined long-term monitoring program will be implemented if required and if technically feasible.	Currently, there is no feasible or cost effective corrective action technology to address test cavities and associated subsurface contamination that will prevent risk.	Subsurface restrictions and institutional controls will be maintained and long-term hydrologic monitoring will be implemented based on the risk assessment and natural gas modeling results.
Surface soil	A corrective action investigation and risk assessment for the surface have indicated that there is no remaining surface contamination above regulatory limits. The surface of the site has been clean closed as agreed to be the DOE and the State of Colorado.	A human health risk assessment for the surface has indicated that the risk from exposure to contaminants is below regulatory limits.	Previous site cleanup confirmed.	No further action required for surface soils.	No further action required for surface soils.	The anticipated future surface land use will be open space for grazing and recreation.

Figure 4.0 - Rio Blanco Site Conceptual Site Model - Current State and End State



*Note: there are no remaining contaminants of concern in the surface soils.

4.1 Hazard Area 1 – Subsurface

The Rio Blanco Site subsurface area consists of the three test cavities and plugged emplacement shaft. The test consisted of the simultaneous detonation of three nuclear devices within one 7,000 ft deep well. The explosives were located between 5,838 and 6,689 ft bgs, and were designed to fracture a 1,300 ft section of the Fort Union and Mesaverde sandstone formations. The simultaneous detonation of the three 33 kt nuclear devices created a cylindrical chimney with an overall height of 1,350 ft and a diameter of approximately 160 ft. The maximum extent of fracture from the centerline of the chimney is less than 400 ft. During production testing of the RB-E-01 Well, it was concluded that the three detonation cavities were not in communication; therefore, the chimney height is probably an overestimate (DOE/NV, 1988).

Cleanup associated with subsurface contamination included removing all equipment and materials and plugging and abandoning the emplacement well. The DOE/NSO does not plan to remediate the subsurface contamination because of the lack of feasible technologies for removing radioactive contamination from subsurface cavities formed by underground nuclear tests. Currently, the EPA annually samples 15 locations on and around the Rio Blanco Site, including four springs, four surface sites, and five wells, three of which are located near the cavities (EPA, 2002). No radioactive materials attributable to the Rio Blanco test were detected off site in the samples taken between 2000 and 2002 (NNSA/NV, 2002).

Subsurface characterization is currently underway at the Rio Blanco Site. Natural gas is expected to be the main contaminant migration pathway. Based on the historic use of the site and characterizations conducted at similar sites, plutonium, tritium, and mixed fission products are expected to be present in the subsurface, with gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment.

The subsurface contamination is being addressed by implementing an end state approach based on defining a contaminant boundary at the Rio Blanco Site and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the existing restriction boundary. Migration to the existing restriction boundary, both under non-stressed and stressed (production) conditions is being evaluated. If migration is found to be significant (which may be determined by a risk assessment), then the restriction zone will be enlarged. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This approach will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the dual-phase radionuclide model will be re-evaluated to determine if the drilling restriction area and associated institutional control need to be changed.

The DOE/NSO will continue to investigate and model subsurface contamination (DOE/EM, 2001). According to the Life-Cycle Baseline Revision 5, subsurface closure of the Rio Blanco Site is expected to be completed in FY 2009. The RBES for the subsurface of the Rio Blanco Site will be to continue monitoring and maintenance of institutional controls indefinitely.

4.2 Operational Area 1 – RB-E-01 Drill Pad

The SGZ (Map 4.0b) for the Rio Blanco test was located at the RB-E-01 Emplacement Well on the RB-E-01 Drill Pad. The RB-E-01 Drill Pad is an irregularly shaped area that covers approximately 3.2 acres. Surface features on the drill pad include the SGZ monument, Well RB-D-01, Well RB-S-03, and a 4.5-in. diameter, 10-ft deep metal pipe, which is all that remains of Well RB-W-01. The EPA samples Well RB-D-01 annually as part of the LTHMP. There is no surface expression of the RB-E-01 Mud Pit (NNSA/NV, 2002).

During the corrective action investigation, soil samples were collected in the RB-E-01 area. No concentrations of chemical COCs exceeded established screening levels in the samples collected (NNSA/NV, 2002).

Cesium-137 was the only radioisotope identified above the minimum detectable concentration (MDC). The ^{137}Cs detected in the samples falls within the average ^{137}Cs fallout deposition concentration range for the state of Colorado and is considered to be at background concentrations (NNSA/NV, 2002).

Tritium was identified below the requested MDC but above the sample-specific MDC in a small number of soil samples collected at the RB-E-01 area. The concentration of tritium detected in the soil samples was compared with the 110 pCi/g soil concentration that is deemed compliant with the 25 millirem per year (mrem/yr) unrestricted release dose limit in Title 10 *Code of*

Federal Regulations Part 20, 1402 (NNSA/NV, 2002; CFR, 1999). The reported tritium soil activity sample results are well below the 110 pCi/g screening limit (NNSA/NV, 2002).

Samples were also collected for the purpose of characterizing investigation-derived waste (IDW). No hazardous waste constituents were identified above regulatory levels (NNSA/NV, 2002).

4.3 Operational Area 2 – Flare Stack Location

The Flare Stack was located on the ridge northwest of the RB-E-01 Well. Natural gas generated from RB-E-01, RB-AR-2, and FCG No.1 was burned off at the Flare Stack during the production testing and project assessment phase conducted between 1973 and 1976. The Flare Stack location was primarily undisturbed, with the exception of cleared vegetation and the construction of a concrete foundation for the flare stack (DOE/NV, 2000b).

During the corrective action investigation, soil samples were collected in the Flare Stack area. No concentrations of chemical COCs exceeded established screening levels in the samples collected (NNSA/NV, 2002).

Cesium-137 was the only radioisotope identified above the MDC. The ^{137}Cs detected in the samples falls within the average ^{137}Cs fallout deposition concentration range for the state of Colorado and is considered to be at background concentrations (NNSA/NV, 2002).

No tritium was identified above the MDC or the sample-specific MDC in soil samples collected at the Flare Stack (NNSA/NV, 2002).

Samples were also collected for the purpose of characterizing IDW. No hazardous waste constituents were identified above regulatory levels (NNSA/NV, 2002).

4.4 Operational Area 3 – RB-AR-2/FCG No. 1 Drill Pad

The RB-AR-2 and FCG No. 1 Drill Pads are a roughly rectangular contiguous area covering approximately 3.2 acres. The only remaining surface feature at RB-AR-2/FCG No. 1 is the wellhead marker for the plugged and abandoned FCG No. 1. There is no wellhead marker for RB-AR-2, but there is a small topographic low at the northeast corner of the RB-AR-2 Mud Pit (NNSA/NV, 2002).

RB-AR-2 was the alternate reentry well drilled into the Rio Blanco test cavities. RB-AR-2 was plugged and abandoned in July 1976. FCG No. 1 was used for the disposal of radioactively contaminated fluids during the Rio Blanco test's performance and site restoration activities. Tritiated water generated during production tests and early site restoration activities was injected into FCG No. 1 between 5,630 and 6,735 ft bgs. During site restoration activities in August 1976, the lower injection zone of FCG No. 1 was abandoned and the well was recompleted as a single gas well from the upper producing interval. It was anticipated that this well could be returned to gas-producing status after being recompleted; however, the well continued to produce tritiated water with the natural gas and could not be used. FCG No. 1 was shut-in on February 1, 1977, and was plugged and abandoned in July 1986 (DOE/NV, 2000b).

During the corrective action investigation, soil samples were collected in the RB-AR-2/FCG No. 1 area. Concentrations exceeding the screening level of 1,000 milligrams per kilogram (mg/kg) for TPH-DRO were detected in three of the samples. In addition, one sample exceeded the screening level of 300 mg/kg for total lead. However, the elevated samples were taken at depths ranging from 5 to 12 ft bgs and do not exceed the allowable concentration of 10,000 mg/kg that is protective of human health and the environment, as documented in the risk assessment. Therefore, an increased risk to human health from exposure to these COCs is not expected (NNSA/NV, 2002).

Cesium-137 was the only radioisotope identified above the MDC. The ^{137}Cs detected in the samples falls within the average ^{137}Cs fallout deposition concentration range for the state of Colorado and is considered to be at background concentrations (NNSA/NV, 2002).

Tritium was identified below the requested MDC but above the sample-specific MDC in a small number of soil samples collected at the RB-AR-2/FCG No. 1 area. The concentration of tritium detected in the soil samples was compared with the 110 pCi/g soil concentration that is deemed compliant with the 25 mrem/yr unrestricted release dose limit in Title 10 *Code of Federal Regulations* Part 20, 1402 (NNSA/NV, 2002; CFR, 1999). The reported tritium soil activity sample results are well below the 110 pCi/g screening limit (NNSA/NV, 2002).

Samples were also collected for the purpose of IDW characterization. No hazardous waste constituents were identified above regulatory levels (NNSA/NV, 2002).

4.5 Operational Area 4 – RB-U-4 Drill Pad

The RB-U-4 Drill Pad covers approximately 2 acres, and is the location of the RB-U-4 Gas Reservoir Formation Evaluation Well. RB-U-4 was drilled approximately 624 ft northeast of RB-E-01, outside the fractured zone produced by the Rio Blanco test explosives, to a total depth of 7,025 ft. RB-U-4 was completed for gas production; however, natural gas could not be obtained until a conventional hydraulic fracturing treatment was performed. The initial production rate of 53,000 standard cubic feet (SCF) per day decreased to 7,000 SCF per day in approximately three weeks, and on January 29, 1975, the well was shut-in. RB-U-4 was plugged and abandoned in 1976. No radioactivity was ever detected in this well (DOE/NV, 2000b). The only surface feature on the drill pad is the RB-U-4 Wellhead marker (NNSA/NV, 2002).

During the corrective action investigation, soil samples were collected at the RB-U-4 area. Concentrations exceeding the screening level of 1,000 mg/kg for TPH-DRO were detected in two of the samples collected. In addition, one sample exceeded the screening level of 300 mg/kg for total lead. However, the elevated samples were taken at depths ranging from 5 to 12 ft bgs and do not exceed the allowable concentration of 10,000 mg/kg that is protective of human health and the environment, as documented for the risk assessment. Therefore, an increased risk to human health from exposure to these COCs is not expected (NNSA/NV, 2002).

Cesium-137 was the only radioisotope identified above the MDC. The ^{137}Cs detected in the samples falls within the average ^{137}Cs fallout deposition concentration range for the state of Colorado and is considered to be at background concentrations (NNSA/NV, 2002).

No tritium was identified above the MDC or the sample-specific MDC in soil samples collected at the RB-U-4 area (NNSA/NV, 2002).

Samples were also collected for the purpose of IDW characterization. No hazardous waste constituents were identified above regulatory levels (NNSA/NV, 2002).

5.0 References

BLM, see U.S. Department of the Interior, Bureau of Land Management.

CER Geonuclear Corporation. 1971. *Biological/Ecological Considerations for Project Rio Blanco, Volume II*. Las Vegas, NV.

Chapman, J., S. Earman, and R. Andricevic. 1996. *Assessment of Hydrologic Transport of Radionuclides from the Rio Blanco Underground Nuclear Test Site, Colorado*, DOE/NV/11508--19, Publication No. 45151. Las Vegas, NV: Desert Research Institute.

CFR, see *Code of Federal Regulations*.

Code of Federal Regulations. 1999. Title 10 CFR Part 20.1402, "Radiological Criteria for Unrestricted Use." Washington, DC: U.S. Government Printing Office.

Cooper, C.A., and J. Chapman. 2001. *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs*, DOE/NV/13609--15, Publication No. 45186. Las Vegas, NV: Desert Research Institute.

Cooper, C.A., and C. Shirley. 2004. *Evaluation of Gas-Phase Flow and Transport at the Rio Blanco Underground Nuclear Test Site*. In publication. Las Vegas, NV: Desert Research Institute.

DOE, see U.S. Department of Energy.

DOE/EM, see U.S. Department of Energy, Office of Environmental Management.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

EPA, see U.S. Environmental Protection Agency.

Federal Register. 1968. Public Land Order 4522, "Colorado, Utah, and Wyoming; Withdrawal for Oil Shale," Vol. 33, No. 186. 24 September. Washington, DC: U.S. Government Printing Office.

Federal Register. 1973. Public Land Order 5344, "Colorado; Withdrawal of Lands for Atomic Energy Commission," Vol. 38, No. 81. 27 April. Washington, DC: U.S. Government Printing Office.

Federal Register. 2002. Public Land Order 7516, "Revocation of Oil Shale Withdrawals; Colorado," Vol. 67, No. 51. 15 March. Washington, DC: U.S. Government Printing Office.

Federal Register. 2003. Public Land Order 7582, "Colorado; Withdrawal of Public Land and Reserved Mineral Interest for the Rio Blanco Project Experimental Site," Vol. 68, No. 181. 18 September. Washington, DC: U.S. Government Printing Office.

Johnson, R.C. 1989. *Geologic History and Hydrocarbon Potential of Late Cretaceous-Age, Low-Permeability Reservoirs, Piceance Creek Basin, Western Colorado, Chapter E. of Evolution of Sedimentary Basins – Uinta and Piceance Basins*. U.S. Geological Survey Bulletin, 1787, pp. E1-E51.

Johnston, J. (Stoller-Navarro Joint Venture). 2003a. Personal communication to T. Santor (Stoller-Navarro Joint Venture) regarding the land status of Offsites locations, 7 October. Las Vegas, NV.

Johnston, J. (Stoller-Navarro Joint Venture). 2003b. Personal communication to T. Santor (Stoller-Navarro Joint Venture) regarding the land use plans and ownership of Offsites locations, 7 October. Las Vegas, NV.

NNSA/NV, see U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

Smith, D.K. 2001. *Unclassified Radiological Source Term for the Nevada Test Site Areas 19 and 20*, UCRL-ID-141706. Livermore, CA: Lawrence Livermore National Laboratory.

Stoner, D. (Colorado Department of Public Health and Environment). 2003. Letter to R.C. Wycoff, (U.S. Department of Energy, Environmental Restoration Division) regarding approval of surface closure at the Rio Blanco Site, 11 February. Grand Junction, CO.

Toman, J. and H.A. Tewes. 1972. *Project Rio Blanco: Phase I Technical Studies*, UCID-15968. Livermore, CA: Lawrence Livermore Laboratory.

U.S. Census Bureau. 2000. *Your Gateway to Census 2000, State and County Quick Facts,* Census 2000 Home Page as accessed at http://www.census.gov/main/www/cen2000.html on October 2, 2003.

U.S. Department of Energy. 2003. DOE Policy No. 455.1, "Use of Risk-Based End States." Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Corrective Action Investigation Report for the Rio Blanco Site, Colorado*, DOE/NV--860. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1988. *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas, Volume II*. In publication. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1993a. *Class III Cultural Resources Survey of the U.S. Department of Energy Rio Blanco Gas Stimulation Test Site Rio Blanco County, Colorado*, DOE/NV/10972--57. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1993b. *Floodplains and Wetlands Survey Results for the Rulison and Rio Blanco Sites, Colorado*, DOE/NV/10972--59. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1993c. *Sensitive Species Survey Results for the Rulison and Rio Blanco Sites, Colorado*, DOE/NV/10972--55. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000a. *Human Health and Safety Risk Summary Offsites Test Areas*. In publication. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000b. *Site Characterization Work Plan for the Rio Blanco Site, Colorado*, DOE/NV-607. Las Vegas, NV.

U.S. Department of Energy, Office of Environmental Management. 2001. *A Report to Congress on Long-Term Stewardship, Volume II - Site Summaries*, DOE/EM--563. Washington, DC.

U.S. Department of Energy, Office of Environmental Management. 2003. *Guidance for Developing a Site-Specific Risk-Based End State Vision*. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1996. *White River Resource Management Plan and Final Environmental Impact Statement*. White River, CO.

U.S. Environmental Protection Agency. 2001. *Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup*, EPA-542-F-01-030a. Washington, DC: Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency. 2002. *Annual Water Sampling and Analysis Calendar Year 2002: RULISON Test Site Area, RIO BLANCO Test Site Area, FAULTLESS Test Site Area, SHOAL Teat Site Area, GASBUGGY Test Site Area, GNOME Test Site Area, EPA-402-R-02-007*. Washington, DC.

Attachment A – Discussion of Variances

The following variance report table is provided in accordance with Appendix D of the Environmental Management End State Vision Development Guidance dated September 11, 2003. The table below does not identify any variances, but does provide information clarifying why there are no perceived differences between the various plans and agreements governing activities at the site. There are no negative impacts in terms of scope, cost, schedule, and risk, and no known barriers to achieving the end state. Based on the above noted belief, the next steps are identified for future activities associated with the Rio Blanco Site. There are no maps provided, as there are no differences between the end state based on the current requirements and the end state based on the end state vision. The maps within the main body of the end state document sufficiently identify pertinent information related to the Rio Blanco Site.

Rio Blanco Site Variance Report

ID No.	Description of Variances	Impacts (in Terms of Scope, Cost, Schedule, and Risk)	Barriers in Achieving the End State	Recommendations
N/A	There are no known variances between the end state, the current Offsites baseline, the DOE/NSO Performance Management Plan, and/or regulatory agreements.	The clean-up decisions made for the Rio Blanco Site are consistent with planned future use as BLM administered land for public use and privately owned land for agricultural use. The State of Colorado has agreed that no further action is required with respect to future surface remediation. The State and the private owner have not expressed opposition to future subsurface characterization activities and have not proposed alternative plans.	None at this time.	Support completion of future subsurface plans and documents and prepare the necessary long-term stewardship information for transfer of the management responsibility of the site subsurface to the Office of Legacy Management.